

## **Mechanistically Based Probability (MBP) Modeling In Design, Fleet Management and Sustainment**

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### **Summary**

Mechanistically based probability (MPB) modeling of damage evolution and distribution is considered in the context of aircraft design, fleet management and sustainment. The modeling approach, based on aging aircraft research over the past decade, is illustrated through considerations of pitting corrosion and corrosion fatigue in aluminum alloys. The need for close interactions between the design and sustainment communities and modelers is highlighted. Such interactions would ensure the development and incorporation of appropriate MBP models and projected service environments, and enhance design and sustainment planning.

The principal goal of the modeling effort is to represent the functional dependence of the rate of evolution of each mode of damage in terms of the relevant key random (materials, mechanical and environmental) variables. Once validated, the model (*vis-à-vis*, experientially based statistical (EBS) models) can be used to *predict* the size and spatial distribution in damage over time. These results then serve as a basis for reliability and safety assessments, fleet management and sustainment (maintenance) planning.

For aircraft aluminum alloys, fatigue cracks nucleate and grow from constituent particles, or from corrosion pits that have been induced by the electrochemical incompatibility between these particles and the alloy matrix. In the presence of a “corrosive” environment, pitting tends to be more rapid (in the early stages of damage growth) than fatigue crack growth from a nucleating particle, or particle cluster, and can drastically reduce fatigue life. Modeling of this process is summarized in this poster, along with characterization of the role of key random variables. The efficacy of this approach is demonstrated through comparisons with teardown inspection data on Boeing 707 and AT-38B aircraft. Identification of deleterious influences of constituent particles has led to the development and introduction of leaner alloys. Extension of this approach to other damage (failure) modes (such as, intergranular attack, exfoliation, stress corrosion cracking) should be considered.

The utility, further development and validation of this approach depend on knowledge of the actual loading and environmental histories at key locations in the aircraft structure. Collection and documentation of quantitative information and its accessibility are essential. Close interactions between the design, sustainment and research communities are warranted.